2019534

KOMEX

KOMEX • H2O SCIENCE • INC
5455 GARDEN GROVE BOULEVARD, SECOND FLOOR
WESTMINSTER, CA 92683-8201, USA
TEL 714 379 1157 FAX 714 379 1160
EMAIL info@losangeles komex com
WEB SITE www komex com

ENVIRONMENT AND WATER RESOURCES

# PERCHLORATE DETECTION IN AHMANSON WELL NO. 1: ENVIRONMENTAL SIGNIFICANCE, ADEQUACY OF ASSESSMENT, AND REGULATORY FRAMEWORK

PREPARED FOR:

**Rally to Save Ahmanson Ranch**

PREPARED BY:

***KOMEX***

5545 Garden Grove Boulevard, 2nd Floor

Westminster, California 92683, USA

December 17, 2002
254-001

# TABLE OF CONTENTS

## LIST OF FIGURES

# 1 INTRODUCTION

## 1.1 PURPOSE

Komex has been retained by Rally to Save Ahmanson Ranch to review available data and information pertaining to the detection of perchlorate in a groundwater sample collected from the Ahmanson Well No. 1, located adjacent to the Ahmanson Ranch. This report presents opinions concerning hydrogeology and groundwater flow, risk to human health and the environment, the regulatory framework, and the adequacy of the investigation associated with the detection of perchlorate in groundwater, as well as potential sources for the perchlorate in groundwater near the Ahmanson Ranch.

## 1.2 COMPLETENESS OF AVAILABLE INFORMATION AND DATA

The opinions set forth in this report are based in part on documents and information, including reports and letters prepared by project proponents, regulatory agencies, and the Santa Susanna Field Laboratory (SSFL). These documents include figures and attachments that in some cases are unreadable and/or missing. The information and opinions presented in this report may be modified as additional data and information are reviewed. Where possible, specific references are cited in this report.

# 2 BACKGROUND

In July 2002, perchlorate was detected in groundwater collected from Ahmanson Ranch Well No. 1 at 28 micrograms per Liter (ug/L; equivalent to parts per billion [ppb]). The concentration recorded in Well No. 1 is significant: the detection of 28 ppb is in the 91st percentile of nearly 5,000 samples taken from State of California drinking water sources for perchlorate analysis (California Department of Health Services [CDHS], 2002).

The State of California recently proposed a public health goal for perchlorate in drinking water ranging from 2 ppb to 6 ppb (California, 2002). Ahmanson Ranch Well No. 1 is located approximately 100 feet northwest of an area proposed for residential and commercial development (**Figure 1**). Although additional reconnaissance sampling has been conducted at the proposed development site, the extent of perchlorate contamination in groundwater in the vicinity of Well No. 1 or in any other areas at the Ahmanson Ranch has not been determined.

Known sources of perchlorate contamination near the Ahmanson Ranch consist of detections in groundwater at the Santa Susana Field Laboratory (SSFL) located approximately two miles to the north (**Figure 1**). At the SSFL, perchlorate was used as a component of the fuel used in some rocket engines that were used for testing. Numerous releases of perchlorate-contaminated water have occurred at the SSFL, and perchlorate and other contaminants have been detected in groundwater, surface water, and soil.

In addition to the detection in Well No. 1, perchlorate has been detected in groundwater offsite of the SSFL to the north and east of the facility. Perchlorate has been detected in 14 shallow groundwater monitoring wells in the Simi Valley area, approximately four miles to the north and northwest of the SSFL (**Figure 2**). Perchlorate has been detected in a groundwater monitoring well approximately one-half mile to the east of the SSFL. Perchlorate has also been detected in a shallow soil sample collected approximately one-quarter mile north of the SSFL.

In light of recent findings in Simi Valley, the detection of perchlorate in Well No. 1 may indicate the potential for widespread perchlorate contamination at the Ahmanson Ranch. Federal and State law require full determination of the extent of contamination from known sources and an assessment of the potential risk to humans and the environment.

Until a thorough assessment is completed, the source and extent of perchlorate contamination in Well No. 1 cannot be determined and potential risks to humans and the environment cannot be quantified, although there is the significant potential for human and ecological exposures and the associated risks from this highly toxic contaminant. It is our conclusion that a full characterization of the perchlorate contamination is necessary to ensure the health and safety of the public and the environment.

# 3 PECHLORATE CHARACTERISTICS AND SOURCES

## 3.1 FATE AND TRANSPORT

Perchlorate ($ClO_4^-$) is an anion that contaminates groundwater and surface waters, where it originates from dissolution of ammonium, potassium, magnesium, or sodium salts. Perchlorate is exceedingly mobile in aqueous systems and can persist for many decades under typical groundwater and surface water conditions (USEPA, 2002). Ammonium perchlorate, the principal source of perchlorate in the environment, is soluble in water. Perchlorate salts tend to dissociate completely in water and aqueous tissues; therefore, exposure is to the ion and not to the salt. Although highly charged, perchlorate is not attracted to soil particles and is likely to move at the same rate as water through soils. This lack of retardation within the subsurface defines perchlorate as a "conservative" chemical. Perchlorate contamination will therefore move great distances from the source with surface or groundwater. For example, contamination from former perchlorate manufacturing facilities in Henderson, Nevada, has been measured in the Colorado River south of Lake Mead to the U.S.–Mexico border, over a distance of approximately 600 miles.

## 3.2 POTENTIAL SOURCES OF PERCHLORATE CONTAMINATION

### 3.2.1 ROCKET MANUFACTURING AND TESTING

Rocket manufacturing and testing facilities are nearly always associated with perchlorate contamination. According to the State of California (2002), "In general, almost all of the areas where perchlorate contamination has been detected have had some activity involving rocket engines or fuel." The USEPA states, "A major source of perchlorate contamination is the manufacture of ammonium perchlorate for use as the oxidizer component and primary ingredient in solid propellant for rockets, missiles, and fireworks" (USEPA, 2002).

### 3.2.2 FERTILIZERS

According to USEPA (2002), it has long been known that Chile possesses caliche ores rich in sodium nitrate ($NaNO_3$) that, coincidentally, are also a natural source of perchlorate (Schilt, 1979; Ericksen, 1983 as cited in USEPA, 2002). Although noted as a possible source of perchlorate contamination, Chilean nitrates only make up about 0.1% of the U.S. fertilizer market. Most U.S. fertilizers are derived from raw materials other than sodium nitrate and ammonium nitrate ($NH_4NO_3$), and there is no evidence that any ammonium nitrate is derived from Chilean caliche. According to USEPA (2002), based on its low usage, perchlorate from Chilean nitrates cannot represent a continuing, significant anthropogenic source of perchlorate nationwide, especially with its lowered perchlorate content.

Based on the studies reported to date (Collette and Williams, 2000; Gu *et al.*, 2000; Urbansky *et al.*, 2000a; Urbansky *et al.*, 2000b; Robarge *et al.*, 2000; USEPA, 2001b; Williams *et al.*, 2001; DeBorba and Urbansky, 2001 as cited in USEPA, 2002), there is a consensus among researchers from the USEPA, the fertilizer industry, and other Federal and State laboratories that currently used fertilizers are negligible contributors to environmental perchlorate contamination. Products derived from imported Chile nitrates contribute minimally to environmental releases due to their low use and low perchlorate content. Consequently, the USEPA has concluded that further investigation is unwarranted (USEPA, 2001b).

### 3.2.3 FIREWORKS

Perchlorate is a component used in manufacturing fireworks. As the USEPA states, perchlorate contamination has resulted from fireworks manufacturing; however, no widespread incidences of contamination from the usage of fireworks have been documented.

### 3.2.4 OTHER SOURCES

Perchlorate is also used in manufacturing road flares and in air bags. No widespread incidences of contamination from the use of these sources have been documented. Perchlorate use has also been documented in conjunction with the operation of nuclear reactors.

## 3.3 KNOWN USE AND DISPOSAL OF PERCHLORATE NEAR AHMANSON RANCH

Activities conducted at the SSFL include the use of solid rocket propellants containing perchlorate. Perchlorate is a primary oxidizer in solid rocket fuel. Rockets that use perchlorate as a component of fuel include the Titan, Minuteman, and the Space Shuttle programs.

Disposal of perchlorate in unlined pits and surface impoundments has been documented by the (CDHS, 1990). Contamination of groundwater beneath SSFL has been documented in 12 wells at concentrations up to 670 ppb (Montgomery Watson, 2000).

# 4 REGIONAL GROUNDWATER FLOW

Groundwater in the area of the proposed Ahmanson development occurs principally in the Chatsworth Formation under confined and unconfined conditions. The Chatsworth Formation is characterized as a heavily fractured and jointed marine sandstone with a high sand-to-shale ratio. Fractures beneath the SSFL average around 100 microns in aperture (the human hair is approximately 20 microns in diameter), are systematic, and are hydraulically interconnected. Jointing in the Formation strikes principally NE to N with spacing between 15 and 100 feet. Groundwater contamination in the Chatsworth Formation has been identified in 12 wells at the SSFL at concentrations up to 670 ppb.

Although the saturated thickness of the Chatsworth Aquifer has not been fully investigated, groundwater beneath the facility has a strong downward gradient as indicated by the significant differences in groundwater elevations between deep water supply wells and shallow monitoring wells. Groundwater flows downward when elevations of groundwater decrease with depth.

Currently, 17 large-diameter water supply wells exist at the SSFL. These wells are typically open boreholes ranging in depth down to 2,300 feet bgs or to approximately 492 feet below mean seal level (MSL).

Over 200 monitoring wells have been installed at or near the SSFL, including 92 wells installed in the shallow alluvium and approximately 126 wells installed in the Chatsworth Formation to approximately 500 feet bgs or to approximately 1,300 feet above MSL. A discrepancy of almost 1,000 feet exists between the depth of the water supply wells and the depth of the groundwater monitoring wells at the SSFL. Because of downward flow gradients between shallow and deep groundwater zones, water supply wells may act as open conduits to water migration under non-pumping conditions. Under pumping conditions, flow to the deeper groundwater wells may also tend to induce downward gradients and accelerate the recharge of shallow groundwater to the deeper regional aquifer.

Groundwater flow at the SSFL within the Chatsworth Formation is dominated by flow in fractures and joints that are widespread and interconnecting. Groundwater flow at the SSFL has been described as following "complicated flow paths along which there are variable hydrogeologic properties and from an interconnected fracture network." Groundwater velocities within the Chatsworth Formation are estimated to range between 500 and 10,000 feet per year (Montgomery Watson, 2000).

The anticipated dominant direction of groundwater flow beneath the SSFL hilltop is to points of discharge in the surrounding valleys. Some locally occurring faults have been observed to reduce the flow of local shallow groundwater; however, very little information is available for the Burro Flats Fault, which trends northwest to southeast and passes through the south and southwest undeveloped buffer zone area of the SSFL facility. Although the hydraulic properties of this fault are poorly understood, available groundwater elevation data suggest that the Burro Flats Fault does not act as a barrier to groundwater flow to the south and in the direction of the Ahmanson Ranch (Haley and Aldrich, 2001). The controlling mechanism for groundwater flow appears to be interconnected fractures, not faults. The potential for these fractures to transmit contamination and the lack of adequate characterization has been recognized by ATSDR (1999). Little information regarding groundwater is available between the SSFL and wells located at the Ahmanson Ranch.

Surface water and waste water from on-site ponds discharge from the SSFL facility at the two discrete permitted discharge points located on the southern boundary of the SSFL property. Approximately 65% of the surface water has been estimated to run off toward the south, toward Bell Canyon (Ogden, 2000). Losing segments of streams that flow in Bell Canyon indicate that this is an area of recharge, possibly to deep groundwater, which may flow toward Ahmanson Ranch.

Groundwater also surfaces along the hillslopes of Bell Canyon and in adjacent canyons south of SSFL. These springs are likely indicative of shallow groundwater flow and not deeper regional flow.

At the Ahmanson Ranch, strong upward groundwater gradients are observed in irrigation wells as evident by artesian (free-flowing) conditions. Relatively deep wells located in the Upper Las Virgenes Valley, including the Ranch Well No. 1, originally demonstrated strong artesian flow in excess of 30 gallons per minute (gpm). Due to their artesian nature, these wells may represent strong upward groundwater flow and high-pressure conditions that are consistent with a regional discharge area.

The relationship between deep regional recharge and discharge areas are presented on **Figure 2**. The implication of these designations with respect to the migration of contaminants is discussed in **Section 5**.

# 5 EXTENT OF PERCHLORATE CONTAMINATION IN VICINITY OF AHMANSON RANCH

## 5.1 SSFL

Perchlorate contamination has been documented at three areas of the SSFL: Area I (Happy Valley), Area III, and Area IV (Former Sodium Disposal Facility). The maximum perchlorate concentration of 670 ppb was detected in groundwater from a sample collected from approximately 120 feet bgs in a monitoring well located in Area I. Perchlorate has been detected at depths as great as 506 feet bgs in Area I within the Chatsworth Formation.

Our research has revealed that perchlorate has also been detected in stormwater at the SSFL in six samples to a maximum concentration of 8 ppb (Ponek-Bacharowski, 2002). This stormwater is permitted by the Regional Water Quality Control Board to discharge to the south of the SSFL in a tributary to Bell Canyon which drains east toward the San Fernando Valley. Because no treatment of perchlorate is required before stormwater is discharged off site, perchlorate is likely to be found in the surface water runoff from the site at the concentrations that were documented. Approximately 65% of the stormwater runoff at the facility drains toward the south, toward Bell Canyon (Ogden, 2000), including this perchlorate-containing discharge.

The waste containment for the rocket test areas and laboratories consisted of two parallel and looping networks of open channels that drain to a series of surface ponds. As many as 24 ponds were used to dispose of and contain wastes at the SSFL since the facility opened in 1948. The ponds were generally unlined and provided groundwater recharge to the Chatsworth Formation. Approximately five or six times per year, water and contaminants in the ponds were neutralized for pH and flushed into Bell Canyon via two surface discharge locations on the southern boundary of the SSFL (DoE, 1991).

## 5.2 SIMI VALLEY

A recent study by DTSC has documented perchlorate in 15 sampling locations (14 groundwater wells and one soil sample) at a distance of approximately four miles to the northwest of the SSFL (DTSC, 2002). This investigation was triggered by the discovery in 1999 of perchlorate in a well that was constructed to relieve conditions of high groundwater in Simi Valley. The USEPA re-sampled the same well and found similar results. Following this review, DTSC implemented an extensive program to sample soil, wells, springs, and surface water drainages in key locations throughout the Simi Valley (**Figure 2**). The results of this study show that perchlorate was found in fourteen wells at concentrations ranging from 3 to 19 ppb. Perchlorate was also found in a soil sample approximately one-quarter mile north of the facility.

## 5.3 OTHER OFFSITE DETECTIONS OF PERCHLORATE

Perchlorate has been detected in a well approximately 2,500 feet to the east of the SSFL in Well OS-16 at 4 ppb.

## 5.4 AHMANSON WELL NO. 1

Groundwater samples were collected from Well No. 1 in August 2002 at depths of approximately 50 feet, 450 feet, and 550 feet below the top of the well casing. Prior to sampling, the well was purged for at least 8 hours and for a couple of hours on the following day immediately before collecting samples. Approximately 20,000 gallons of water were purged from the well prior to sampling. The well was reported to be flowing under artesian conditions at approximately one gpm.

Perchlorate was detected in a groundwater sample collected at approximately 550 feet bgs at a concentration of 28 ppb. Development records indicate that the well was blocked at approximately 570 feet bgs and that the water was collected directly from the purge stream. It has been reported (Klienfelder testimony, December 10, 2002) that black murky water (possibly oily in nature) was observed and extracted from the well at about the depth of blockage. No further information characterizing this observation was available from the information reviewed, and apparently no further testing to delineate and characterize groundwater conditions at Well No. 1 has been performed.

## 5.5 OTHER AHMANSON RANCH WELLS

According to the Hazards and Hazardous Materials Background Information Section of the SEIR (2002), Psomas installed six shallow groundwater monitoring wells in October and November 2000. According to the SEIR, the wells were installed in "canyon bottoms and sample near-surface groundwater." Depths to groundwater in the wells varied from 5 feet bgs to 30 feet bgs. On February 27, 2002, Psomas sampled the six groundwater wells, five surface water streams, and one deep groundwater well (Well No. 1). According to the SEIR, the samples from the wells were analyzed for pesticides, PCBs, volatile organic compounds, hardness, odor, color, "some metals, as well as bacteriological constituents, such as E.coli, and streptococcus." From the text of the SEIR, it appears that the samples were not analyzed for the full suite of contaminants found at SSFL (*i.e.* perchlorate, radionuclides, or n-nitrosodimethylamine [NDMA]). According to the SEIR, the "results did not indicate that contaminants from the Santa Susanna facility were impacting the site." This claim is speculative since the analytical results for the February 27, 2002, sampling event of the six shallow groundwater wells at the Site by Psomas, or the sampling events that would have occurred after the installation of the wells at the site by Psomas, were not included in the SEIR. The wells were not sampled for all constituents, and they were only tested very shallow water.

## 5.6 SUPPLEMENTAL SAMPLING ON THE AHMANSON PROPERTY

As detailed in the Kleinfelder's Report of Environmental Sampling (2000), Kleinfelder was retained "to perform environmental sampling of soil and surface water on the Ahmanson Ranch Project site, to assess whether chemical or radiological constituents have migrated to the Ahmanson Ranch Project site from the Santa Susanna Field Laboratory (SSFL), or from other off-site industrial uses."

To achieve this objective, Kleinfelder used a biased sampling strategy wherein:

> *Soil samples were collected from undeveloped areas within the Ahmanson Ranch Project site. Soil was sampled at the confluence of streams in drainage areas most likely to intercept materials potentially conveyed from the direction of the SSFL to the north. Surface water samples were collected from streams within the East Las Virgenes Creek (or its tributaries) and the Las Virgenes Creek (or its tributaries)...The surface samples were distributed across the Ranch at approximate distances of 1 mile.*
>
> *Kleinfelder performed a site reconnaissance on July 14, 1999 with representatives of ALC (Ahmanson Land Corporation) to select soil boring and surface water sampling locations. The site for 6 soil locations and 3 surface water locations were selected and agreed upon by ALC.... Soil sampling locations were selected at the confluence of streams in drainage areas likely to intercept materials potentially conveyed from the direction of the SSFL to the north. Surface water samples were collected from streams within East Las Virgenes Canyon (sample W-1) and from streams within Las Virgenes Canyon (samples W-2 and W-3).*

No perchlorate was detected in any of the soil or surface water samples collected at the site.

Radionuclides were detected in soil and groundwater at the Ranch. Although the levels measured at the site were determined by Kleinfelder to be "within background concentrations of radionuclides distributed in soils, rocks, and water," the report failed to note that the values of Radium$^{226}$ and Thorium$^{232}$ were outside the range of values found for those isotopes in California. The Report also fails to explain adequately the presence of Potassium$^{40}$, Cadmium$^{109}$, Cesium$^{137}$, Thorium$^{228}$, Thorium$^{230}$, and Uranium$^{235}$ that did not have reported background concentrations.

When considering the presence of radionuclides in the environment, it is import to consider that body of knowledge regarding the carcinogenic potential of radionuclides. Radiation is known to be genotoxic (*i.e.* it reacts directly with DNA) and an initiator of cancer. Small doses may lead to significant changes in the receptor (cancer).

On February 27, 2002, Psomas sampled the six shallow groundwater wells, five surface water streams, and one deep groundwater well (Well No. 1). As detailed above, although the SEIR claims that the "results did not indicate that contaminants from the Santa Susanna facility were impacting the site," this claim is speculative since the analytical results were not included in the SEIR.

# 6 POTENTIAL EXPOSURE TO PERCHLORATE CONTAMINATION AND RISK

## 6.1 EXPOSURE PATHWAYS

The attached figure (**Figure 4**) indicates possible exposure pathways that potentially exist in the environment at the proposed development site or downstream of the site. Major pathways for exposure include ingestion of soil, groundwater, and surface water. The source of perchlorate detected in Well No. 1 is not known with certainty; however, its presence is significant because it may indicate the potential for risk to human health and the environment.

In general, chemicals introduced into the environment may adsorb to soils, dissolve into bodies of water, leach from soil, volatilize from either soil or water into the atmosphere, or be absorbed from soil by vegetation. The fate and transport of chemicals detected at the proposed development site are governed by properties of the chemicals, as well as by properties of the media in which they are found.

Once released to the environment, perchlorate is not significantly changed. Since perchlorate is conservative, it will move at the same rate as water and will not be retarded by the organic carbon in soil. Given the hydrogeology of the area, a release of perchlorate from a source such as the SSFL could be expected to move in groundwater beneath the Ahmanson Ranch. Perchlorate in groundwater may also communicate with surface waters, providing exposure to humans or animals that may come in contact with the water.

If a source of perchlorate is located at the proposed development site from an unknown source (illegal dumping, airborne deposition), then the proper due diligence may not have been performed. Exposure to perchlorate in the soil is possible via the inhalation of soil particles, ingestion of foodstuff grown on the soils, or the ingestion of organ meats from animals raised at the site.

Whether or not water is pumped from Ahmanson Ranch Well No.1, the potential for a larger environmental problem exists. Without a thorough investigation of all exposure pathways (soil, water, air), construction activities at the site may inadvertently distribute the problem over a larger area (movement of contaminated soils) or inadvertently expose the public via a number of unforeseen pathways. Exposure pathways for perchlorate in the environment may include soil (dust inhalation), and water (dermal absorption, ingestion), and ingestion of foodstuffs contaminated with perchlorate (foodstuffs grown with contaminated water and organ meats from animals ingesting contaminated foodstuffs or water).

Groundwater contaminated with perchlorate may be in communication with other groundwater units that are used for drinking water supplies. Perchlorate is known to be absorbed by root stems and is taken up by the leaves of plants (USEPA, 2002). Ingestion of plants/foodstuffs grown with contaminated water may represent a significant potential exposure pathway. Irrigation with water from Ahmanson Well No.1 is likely to lead to the accumulation of perchlorate in plants grown at the site or downstream of the irrigation runoff.

According to USEPA (2002), fish, aquatic invertebrates, and aquatic plants may be exposed directly to concentrations of perchlorate in surface waters. These concentrations may result from surface runoff from perchlorate-contaminated soil, from leaching of perchlorate from contaminated soil via shallow groundwater, or from direct discharge of aqueous wastes. Surface or groundwater may be used for irrigation, resulting in direct exposure of soil invertebrates or plants (USEPA, 2002).

## 6.2 RISK TO HUMAN HEALTH

Perchlorate is known to cause significant health effects when ingested. Ingestion of as little as 1 ppb of perchlorate is believed to be physiologically significant (USEPA, 2002; OEHHA, 2002). The USEPA, the CDHS, and other state environmental and public health agencies agree that perchlorate is a significant environmental contaminant. CDHS established an action level (AL) in 1997 requiring that drinking water purveyors start sampling for perchlorate in their supplies. In 1999, DHS adopted a regulation that added perchlorate to the list of unregulated chemicals requiring monitoring. In 2002, CDHS lowered the AL from 18 ppb to 4 ppb, based upon the potential threat to public health. Health and Safety Code §116275 [Chapter 425, Statutes of 2002, SB 1822 (Sher)] requires DHS to adopt a maximum contaminant level (MCL) for perchlorate by January 1, 2004.

Health and Safety Code §116275 also requires the Office of Environmental Health Hazard Assessment (OEHHA) to establish a perchlorate public health goal (PHG). The draft 2- to 6-ug/L PHG (OEHHA, 2002) is based on the inhibitory effect of perchlorate on the uptake of iodide by the thyroid gland. Such an effect decreases production of thyroid hormones, which are needed for prenatal and postnatal growth and development, as well as for normal body metabolism. The 'acceptable' concentration of perchlorate according to the State is in the same range of concentration as known and suspected carcinogens such as benzene, trichloroethene, and tetrachloroethene (CCR, 2002).

Perchlorate's mode of action is to disrupt the thyroid function. In adults, the thyroid helps regulate the metabolism. In children, the thyroid plays a major role in proper development and in the regulation of the metabolism. Impaired thyroid function in pregnant mothers may impact the fetus and newborn resulting in changes in behavior, delayed development, and decreased learning capability. Changes in thyroid hormone levels may also lead to thyroid gland tumors.

USEPA has spent a considerable effort to define a reference dose (RfD) for perchlorate. Because of the research identified by the Interagency Perchlorate Steering Committee and funded by the USEPA, the RfD was lowered to 0.00003 mg/kg/day in a recent comprehensive risk assessment and toxicological review draft submitted for peer review (USEPA, 2002). The Drinking Water Equivalency Level (DWEL), or acceptable level of perchlorate in water, was calculated by USEPA at this level as 1 ppb. Based upon available research, including USEPA's, the OEHHA set a PHG of 2 ppb to 6 ppb. Exposure to concentrations above these thresholds are likely to lead to significant health effects.

## 6.3 ENVIRONMENATAL HEALTH CONCERNS

The ecological risks perchlorate poses are not well understood. According to USEPA, at least one important issue remains unresolved concerning the exposure of environmental receptors (USEPA, 2002):

- Because the available data on accumulation in terrestrial and aquatic vascular plants are from studies that were not designed to quantify accumulation factors, the accumulation of perchlorate in terrestrial and aquatic plants should be further investigated.

Also requiring further attention are issues related to the effects of potential perchlorate exposure (USEPA, 2002):

- The effects of exposure of aquatic plants should be determined.
- The effects of exposure of noncrustacean invertebrates should be determined.
- The effects of dietary exposure to perchlorate should be determined in birds and in herbivorous or litter-feeding invertebrates.
- The effects of dietary and cutaneous exposure to perchlorate should be determined for adult amphibians and aquatic reptiles.

- If perchlorate occurs at significant levels in estuarine systems, its toxicity in saline waters should be determined.

Recent peer-reviewed studies demonstrate that perchlorate has the potential to bioaccumulate and cause significant developmental problems in frogs (inhibition of fore-limb emergence and sex ratios) exposed to as little as 5 ppb (Goleman *et. al.*, 2002a & b; TRW, 2002). Some animals within the Las Virgenes Watershed may be specially protected species (red-legged frogs). Peer-reviewed articles clearly show that perchlorate poses a "threat to normal development and growth in natural amphibian populations." Environmentally relevant concentrations resulted in a skewing of sex ratio, inhibition of forelimb emergence, the percentage of animals completing tail resorption, and hindlimb development.

## 6.4 ADEQUACY OF MITIGATION MEASURES PROPOSED IN SEIR

The SEIR fails to properly determine the appropriate mitigation measures for contamination that may exist at the site. Potential exposure pathways are complete for contaminated groundwater from Ahmanson Well No.1 to reach the surface through pumping or through springs and other surface water discharges. Following further characterization of the extent of contamination, mitigation measures should include restrictions for human contact with this water and remediation of the source of contamination to prevent harm to aquatic habitat.

The detection of perchlorate in the Ahmanson Well No. 1 may be the leading edge of a plume of contamination that may contain other contaminants, including trichloroethene (TCE), known to exist at the SSFL. Without hydraulic containment of the contaminants noted at SSFL—including perchlorate, other components of rocket fuel, and chlorinated solvents—significant further migration of these contaminants may occur.

Given that the well has frequently been described as artesian and produces approximately 30 gpm of water unaided, abandonment of the well will not reduce the potential for groundwater to reach the surface within the Las Virgenes Watershed and is not a proper mitigation measure.

Without fully characterizing the perchlorate contamination and other contamination that may be present in groundwater at Well No. 1, the potential for ecological and human exposure cannot be determined.

# 7 GAPS IN THE CURRENT UNDERSTANDING OF PERCHLORATE CONTAMINATION

## 7.1 INADEQUACY OF SOIL SAMPLING PROGRAM AT AHMANSON RANCH

The SEIR failed to adequately characterize the conditions of the surface soils at the site, which may act as reservoirs for contaminants that will migrate to groundwater and surface water or be direct exposure pathways to humans and a variety of biota.

As detailed in the Kleinfelder's Report of Environmental Sampling (2000), Kleinfelder was retained to conduct the following objective:

> *[T]o perform environmental sampling of soil and surface water on the Ahmanson Ranch Project site, to assess whether chemical or radiological constituents have migrated to the Ahmanson Ranch Project site from the Santa Susanna Field Laboratory (SSFL), or from other off-site industrial uses.*

Although the sampling program was biased (*i.e.* focused on areas where the confluence of streams in drainage areas were most likely to intercept materials potentially conveyed from the direction of the SSFL to the north), it failed to collect enough samples to provide an accurate characterization of the site. Because of the high water solubility of perchlorate salts, perchlorate is unlikely to accumulate via adsorption to irrigated soils, and aqueous perchlorate was not found to adsorb to sand in laboratory reactors (Nzengung, n.d. as cited in USEPA, 2002). According to USEPA, soil concentrations would not be expected to exceed the concentrations in irrigation water (USEPA, 2002). Therefore, the lack of detections of perchlorate in soil samples collected at the site does not preclude the potential for perchlorate to have been released at or near the surface and to have migrated to groundwater with infiltrating water. Sampling perchlorate in soil is unlikely to yield significant data unless the sampling is performed in areas that do not receive much infiltration from water (rain or irrigation) and that contain high concentrations of perchlorate in a solid form.

The depth to which the soil sampling was performed was not adequate to characterize the potential risk to workers and future residents from other contaminants at the site. Workers involved in grading activities and future residents can reasonably be expected to be exposed to contaminants contained in soils at much greater depths (perhaps as deep as 10 feet bgs from the final grade). Future sampling activities that must be performed at the site should characterize contamination at the depths of the final grade and below (at least 10 feet) to protect all potential future receptors.

Although biased sampling may be appropriate as a screening level tool, it is unreasonable to assume that six soil samples over a 2,800-acre site would accurately represent conditions at the site. The number of samples required to give a particular degree of precision can be statistically computed (USEPA, 1983 and 1989a) and depends on the sampling strategy used (USEPA, 1989b). As the number of samples is reduced, the power or ability to accurately determine whether a result is accurate is reduced. For small sample sets, the variation within the samples may mask the true result. Pitard (1989b) has suggested a minimum of 18 sample locations are required to carry out a preliminary study.

In June 2000, the Department of Toxic Substances Control (DTSC) issued "Interim Guidance for Sampling Agricultural Soils" to provide a uniform approach for evaluating former agricultural properties where pesticides have been applied (DTSC, 2002). The guidance was intended to supplement the DTSC Preliminary Endangerment Assessment (PEA) Guidance Manual (Manual), Cal/EPA 1994 (DTSC, 1999). The guidance does not apply to disturbed land, such as land that has been graded in preparation for construction, areas where imported soil has been brought in, or any other activity that would redistribute or impact the soil, other than normal disking and plowing (DTSC, 2002).

DTSC notes that "sampling frequency may vary depending on the size of the site and conditions found." For sites that are frequently disturbed (homogeneous by nature), the distribution of contaminants will be relatively uniform. For relatively undisturbed sites, the distribution of contaminants will not be uniform, and "the sampling rate should be sufficient to characterize each area" (DTSC, 2002).

For sites two acres or less, DTSC recommends that discrete samples should be collected on quarter-acre centers. For sites between two and four acres, DTSC recommends sampling at eight locations, evenly spaced across the site. For sites greater than four acres and up to 20 acres, DTSC recommends eight discrete samples should be collected on half-acre centers, and for sites between 21 and 60 acres, DTSC recommends 15 discrete samples on one-acre centers. For sites between 61 and 100 acres, DTSC recommends 25 discrete samples on one-acre centers. For sites greater than 100 acres, DTSC should be consulted for the appropriate number of sampling locations. Extrapolating from DTSC guidance, a reasonable number of samples for the site could be expected to be up to 700 samples. Six samples for a site this large are woefully inadequate.

The data set used to evaluate the surface soils at the site, which may act as reservoirs for contaminants that will migrate to groundwater and surface water or be direct exposure pathways to humans and a variety of biota, is unlikely to have sufficient statistical power to correctly characterize conditions at the site. This represents a significant flaw in the SEIR.

## 7.2 INADEQUACY OF GROUNDWATER MONITORING PROGRAM AT THE SSFL

Currently over 200 monitoring wells exist at the SSFL facility to monitor the migration of groundwater contaminants, including perchlorate. The existing monitoring plan specifies which wells are to be tested and for what compounds.

An undeveloped buffer zone exists between the active test areas of the SSFL (Area II, II, III, and IV) and the southern SSFL property boundary. The Burro Flats Fault is mapped in the central to northern portion of the buffer zone. The fault trends northwest to southeast and truncates the north-south trending Skyline Fault. Shallow groundwater flow in Chatsworth Formation in the southern portion of the Area I, II, and III is generally to the south with flow in the buffer zone also generally to the south. These general trends appear to be historically consistent prior to 1963 when select water supply wells were actively pumped (*i.e.* throughout the 1940s and 1950s) as well as under non-pumping conditions.

Of the more than 200 wells located at the SSFL facility, only nine groundwater wells are located at five locations in the buffer zone, with only two shallow monitoring wells located south of the Burro Fault. Of these nine wells, only one well (Well RD-6) is sampled for perchlorate and only in the first quarter of each year. Well RD-6 is completed in the upper portions of the Chatsworth Formation and extends to approximately 260 feet bgs (1,357 feet MSL). No off-site monitoring to the south is performed as part of the current monitoring plan in effect for the SSFL.

ATSDR stated, in their review of the adequacy of the assessment activities at SSFL, "Because the potential for deep fracture flow from the site has not been adequately characterized, there is a potential for substances in ground water to discharge at springs or down-gradient water wells along the margins of Simi and San Fernando Valleys" (1999).

It is our opinion that the existing monitoring plan at the SSFL is not adequate to monitor or detect the potential migration of perchlorate in groundwater to the south from the SSFL, in addition to the areas that ATSDR identified as contaminant pathways, particularly now that perchlorate contamination has been identified off site to the south of SSFL.

## 7.3 INADEQUACY OF GROUNDWATER CHARACTERIZATION AND SAMPLING PROGRAM (PERCHLORATE ISSUE) AT AHMANSON RANCH

Numerous irrigation wells and abandoned oil wells exist on the Ahmanson Ranch and in the Upper Las Virgenes Valley. State records indicate that as many as ten wells may have existed on the Ranch since 1932, ranging in depth up to 1,000 feet bgs. Of these wells, two wells (1,000-foot Ahmanson Ranch well located 01N/17W-04N01S and 368-foot Ahmanson Ranch Well located at 01N/17W-18F01S) are reported to be artesian (*i.e.* flowing). The status of many of the wells in the region is unknown and uncertain.

To date, data reviewed indicate that only Well No. 1 at the Ranch has been tested in conjunction with the EIR and SEIR. Based on the testimony provided by Kleinfelder (December 10, 2002), blackish murky water of possible oily nature was observed at approximately 570 feet bgs during development. The source of this murky water and composition of this contaminant is not known or understood. In addition, by failing to isolate the various depths during their testing, the sampling methodology could have led to significant dilution of the perchlorate contamination found at Well No. 1. Thus, the actual level of perchlorate in this "murky" zone could have a concentration significantly in excess of 28 ppb.

Given the uncertainty associated with the observations made during the sampling of Well No. 1, and the subsequent detection of perchlorate, a comprehensive and agency-approved program to locate, recondition, sample, and evaluate groundwater quality and water resources at the Ahmanson Ranch and in the Upper Las Virgenes Valley is required to fully characterize groundwater conditions for the SEIR and EIR. The need for a characterization and investigation program that may include installing additional wells to full identify and characterize potential groundwater contamination is also required.

## 7.4 LACK OF TESTING FOR OTHER CONTAMINANTS ASSOCIATED WITH ROCKET TESTING

Other contaminants are commonly associated with rocket fuels. These include NDMA, a common component used to manufacture 1,1-dimethylhydrazine for liquid rocket fuel. NDMA is highly mobile in soil and groundwater.

Based on animal studies, NDMA has been identified as a probable human carcinogen by the USEPA. It is also identified as a chemical "known to the state to cause cancer," under California's Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65). NDMA is a human carcinogen at its detection limit of 0.002 ppb; however, because of limitations in analytical sensitivity, the action level set by CDHS for NDMA is 0.01 ppb in drinking water.

NDMA has been detected in four wells at the SSFL facility. The maximum concentration detected was 110 ppb in Well SH-04. Wells SH-03, HAR-16, and HAR-20 had detections of NDMA at 55 ppb, 26 ppb, and 10 ppb, respectively.

No sampling or analysis for NDMA has been conducted in Well No. 1 or in other groundwater wells that are not part of the SSFL sampling program (RWQCB, 2002).

## 7.5 POTENTIAL FOR PERCHLORATE TO ACT AS AN INDICATOR FOR OFF-SITE CONTAMINATION

Because perchlorate flow in groundwater is not retarded, it can be considered a tracer for additional contamination to follow. Other contaminants known to exist at SSFL, including TCE, are bound in high concentrations in the rock matrix. TCE dissolves slowly from these fractures and provides a long-lasting source for the contamination for migrating groundwater. TCE groundwater plumes are known to extend for thousands of feet at many sites.

# 8 REGULATORY FRAMEWORK

For over ten years, the SSFL has been investigated for groundwater contamination with a focus, until recently, on chlorinated solvents and radioactive waste. Perchlorate was not discovered at the site until 1997 when a more sensitive analytical method was developed.

## 8.1 RESOURCE CONSERVATION AND RECOVERY ACT

The USEPA has identified the SSFL as one of 1,714 high-priority facilities nationwide on the Resource Conservation and Recovery Act (RCRA) cleanup list. Investigation and cleanup activities have been conducted under the California Health and Safety Code. The USEPA has delegated the RCRA regulatory authority to the DTSC, who supervises the characterization and assessment activities at the SSFL. DTSC has identified perchlorate as a contaminant of concern at the SSFL and DTSC requires monitoring for perchlorate in groundwater.

## 8.2 CLEAN WATER ACT

The Regional Water Quality Control Board (RWQCB) requires perchlorate monitoring in surface water at the SSFL under a Clean Water Act National Pollutant Discharge Elimination System (NPDES) permit. The NPDES permit is to be reissued in early 2003 and will likely require perchlorate monitoring at the two permitted outfalls, which is not currently required.

Federal regulations require that storm water discharges shall not contain a hazardous substance in excess of "reportable quantities" established by (40 CFR 302.4). The RWQCB maintains regulations that require non-stormwater discharges to achieve water quality standards.

Currently, perchlorate has been detected in stormwater at the SSFL at concentrations ranging from 4 ppb to 8 ppb (RWQCB, 2002). Perchlorate in this stormwater is not treated before discharge into Bell Canyon.

## 8.3 SOURCE IDENTIFICATION

Although perchlorate contamination is usually associated with rocket testing or manufacturing activities, regulatory agencies have not linked off-site detections of perchlorate to the SSFL. In reference to the detections of perchlorate in Simi Valley, DTSC states, "Although no direct link has been drawn between the facility and these sample results, the nearest known perchlorate user is the Santa Susanna Field Laboratory" (DTSC, 2002).

Under RCRA §3013 or California HSC §25359.4, the DTSC has the authority to require characterization of any release that might pose a "substantial hazard" to human health or the environment. Similarly, under RCRA §7003 or California HSC §25359.2, DTSC could require SSFL to address any "imminent and substantial endangerment" that SSFL might pose to human health and the environment. This authority is used where releases are migrating without control and where the public and the environment are likely to be exposed to the contaminants. This authority could also be used to conclusively identify the source of the perchlorate that has been noted in Well No. 1.

At this time, DTSC investigations at SSFL under RCRA are focused on contaminants known to exist at the site. The investigations are ongoing, and no date for completion has been established. An EIR for the groundwater cleanup remedy was to be completed in 2002; however, that report has been indefinitely delayed because the cleanup remedy is not near completion.

DTSC-led investigations that have been conducted off site to date are the equivalent of reconnaissance or screening-level investigations. Investigations conducted by Ahmanson Ranch contractors, including the sampling of Well No. 1, surface water and soil, have been conducted without regulatory oversight and do not conform to guidelines required by regulations.

# 9 CONCLUSIONS

The perchlorate contamination at Well No. 1 needs to be considered in the context of the following facts:

- The only known use of perchlorate near Ahmanson Ranch is at SSFL.
- The only known disposal of perchlorate in the area is at SSFL.
- Perchlorate is known to exist both in groundwater and in surface water at SSFL.
- Other rocket-related contaminants have been identified at SSFL, including NDMA.
- The SSFL facility occupies a ridge top, and both surface water and groundwater flow away from the facility in a radial pattern.
- Perchlorate contamination is detected in a pattern to the north, south, and east of the SSFL.
- 65% of surface water flows from the SSFL to the south and discharges into Bell Canyon.
- Perchlorate contamination has been found in surface water that discharges to the south of SSFL.
- Perchlorate is likely migrating through the heavily fractured Chatsworth Formation from the SSFL into surrounding groundwater areas.
- Perchlorate is likely migrating to depths greater than 2,000 feet through fractures and open large-diameter boreholes.
- The presence of artesian flow conditions observed at the Ranch may indicate that groundwater is discharging to local springs, ponds, and streams in the area of the Ranch.
- Approximately two decades of non-pumping at SSFL has increased the potential for downward migration of perchlorate via open water supply wells.
- Mixing in Well No. 1 could have led to the dilution of the sample collected by Kleinfelder, leading to a sampling result that is lower than the actual concentration of perchlorate in groundwater.
- Viable direct exposure pathways at the site may include exposure to contaminated groundwater through pumping of groundwater, through surface water in communication with groundwater, through direct contact with surficial soils, or from contact with contaminated fugitive dust from construction activities.
- Potential receptors may include humans at or near the site and sensitive ecological receptors.

- Investigations conducted by SSFL for on-site perchlorate contamination have not specifically been designed to assess perchlorate contamination, which migrates in the subsurface in ways that are distinct from other known contaminants (*i.e.* chlorinated solvents), and perchlorate contamination in the vertical and horizontal dimensions is unknown.
- Investigations conducted by DTSC for off-site perchlorate contamination have not followed protocol of RCRA regulations and guidance and therefore have not adequately sampled for perchlorate.
- Investigations conducted by proponents of the ranch have not followed protocol of RCRA regulations and guidance under either California or Federal law.

Given these facts, the SEIR has inadequate information to assess the significant human health and ecological risks posed by the massive construction project at the Ahmanson Ranch. Any credible investigation would follow RCRA guidelines, and would also assess the potential for off-site migration of contaminants from SSFL, including but not limited to perchlorate and other compounds associated with rocket testing, namely NDMA, radionuclides, and hydrazine. These investigations should follow rigorous RCRA guidelines for the investigation of groundwater, including:

- Development of work plans specific to monitoring contamination associated with rockets;
- Construction of monitoring wells off site from the SSFL that are designed to detect contaminant flow through deep fractures; and
- Assessment of risk to human health and the environment posed by migration of contamination off site from the SSFL.

DTSC guidance specifies early action to eliminate sources of contamination to avoid further migration. This should include groundwater contamination at the Ahmanson Ranch, the potential for surface contamination, and stormwater flows at the SSFL that are known to contain perchlorate above regulatory guidelines. The findings of perchlorate in stormwater at SSFL at levels above the California drinking water standards indicate an unmitigated potential for exposure to human health and the environment in Bell Canyon. Additionally, this contaminated discharge serves as recharge to groundwater and may serve as a source of the contamination of the deep groundwater as noted in Well No. 1.

Until these investigations are completed, the vertical and horizontal extent of perchlorate contamination in the vicinity of Well No. 1 will not be known and the consequences of exposure to the contamination cannot be quantified. An agency-approved program to locate, sample, evaluate, and recondition groundwater quality and water resources at the Ahmanson Ranch and in the Upper Las Virgenes Valley, as well as a more thorough consideration of the regional perchlorate, is required to fully characterize groundwater conditions for the SEIR to adequately understand the significant risks to human health and the environment.

# 10 REFERENCES


CCR. 2002. California Code of Regulations, Title 22, Division 4, Chapter 15, Domestic Water Quality and Monitoring.

CDHS. 1990. Comprehensive Groundwater Monitoring Evaluation Federal Fiscal Year 1990-1991. December 31.

CDHS. 2002. Perchlorate in California Drinking Water: Monitoring Update. December 6.

DoE. 1991. Tiger Team Assessment Report, Energy Technology Engineering Center.

DTSC. 2002. Perchlorate Identified in Simi Valley Groundwater. November.

DTSC. 2002. Interim Guidance for Sampling Agricultural Soils (Second Revision). August 26.

DTSC. 2000. Interim Guidance for Sampling Agricultural Soils. June.

DTSC. 1999. Preliminary Endangerment Assessment (PEA) Guidance Manual (Manual). June.

Goleman, W.L., L.J. Urquidi, T.A. Anderson, E.E. Smith, R.J. Kendall, J.A. Carr. Environmentally Relevant Concentrations of Ammonium Perchlorate Inhibit Development and Metamorphosis in Xenopus Laevis. Environmental Toxicology and Chemistry. 21(2) :424-430.

Goleman, W.L., J.A. Carr, and T.A. Anderson. Environmentally Relevant Concentrations of Ammonium Perchlorate Inhibit Thyroid Function and Alter Sex Ratios in Developing Xenopus Laevis. Environmental Toxicology and Chemistry. 21(3) :590-597.

Haley and Aldrich, Inc., 2001. Groundwater Monitoring Quarterly Report, Third 2001, July through September 2001, SSFL, Ventura, California. November 26.

Los Angeles Times, 2002. Article in Los Angeles Times regarding perchlorate detections in wells in the Simi Valley Area. December 5.

Kleinfelder. 2000. Report of Environmental Sampling Ahmanson Ranch Project, Ventura County, California. January 27.

Montgomery Watson, 2000. Technical Memorandum, Conceptual Site Model, Movement of TCE in the Chatsworth Formation, prepared by Montgomery Watson for the Boeing Company, SSFL. April.

OEHHA, 2002, *Public Health Goal for Perchlorate in Drinking Water, Draft,* Office of Environmental Health Hazard Assessment, December.

Pitard, Francis F. 1989b. Class Handouts for a Short Course entitled "Sampling Methodologies for Monitoring the Environment: Theory and Practice." Pierre Gy and Francis Pitard Sampling Consultants. Broomfield, CO, as cited in EPA, 1992.

Ponek-Bacharowski. 2002. Personal communication. Los Angeles Regional Water Quality Control Board.

Rincon, 2002. The Supplemental Environmental Impact Report (SEIR) for the Ahmanson Ranch. Prepared by Rincon and Associates, February.

Slossen and Associates, 2002. Letter to the County of Ventura, by Mr. James Slossen of Slossen and Associates. April 30.

TRW. 2002. Biological Effects of Inadvertent Perchlorate Releases During Launch Operations. TRW Space and Electronics. September 30.

USEPA, 2002. *Perchlorate Environmental Contamination: Toxicological Review and Risk Characterization,* External Review Draft, National Center for Environmental Assessment (NCEA), NCEA-1-0503, January 16.

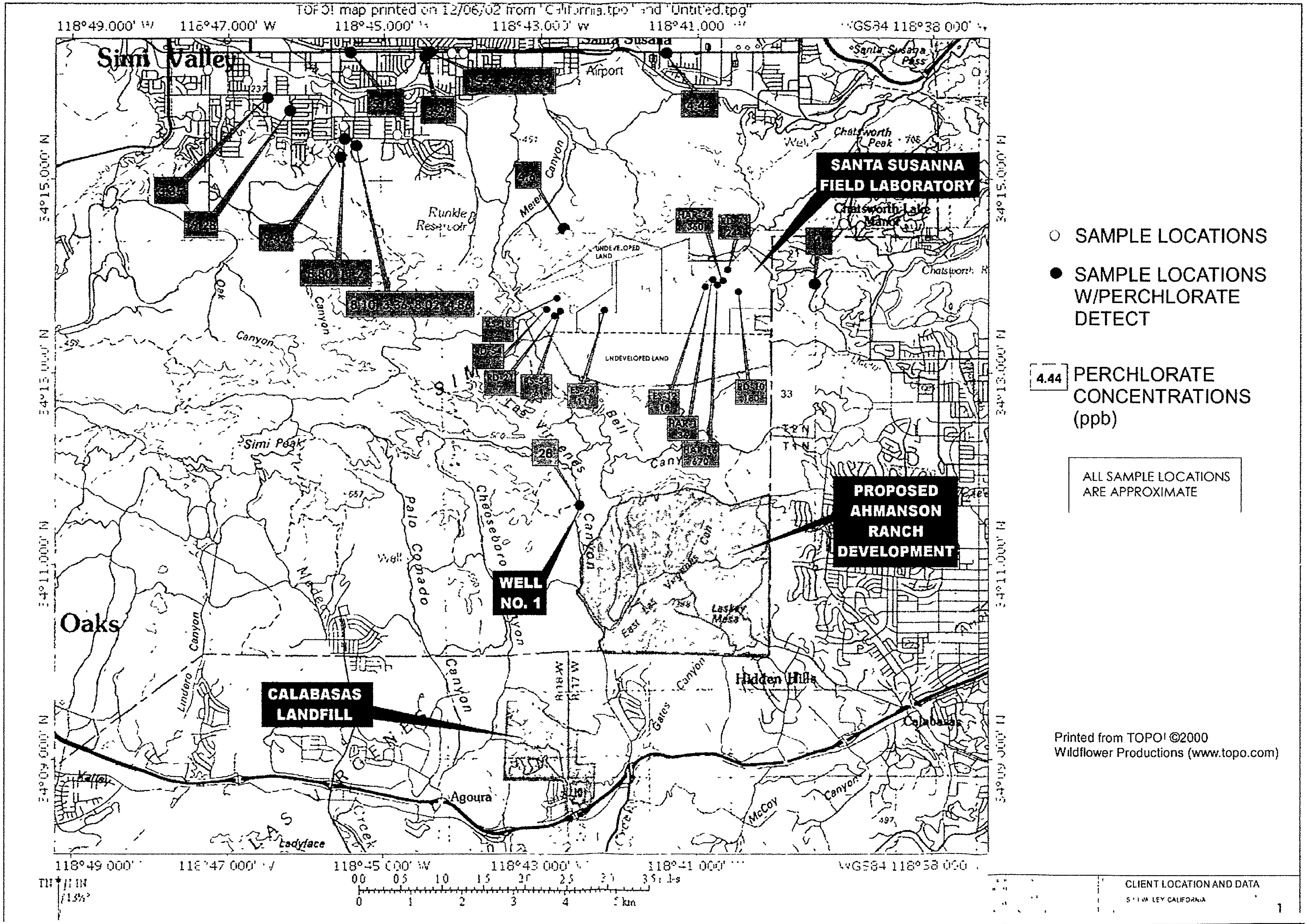
USEPA, 1992. Preparation of Soil Sampling Protocols: Sampling Techniques and Strategies, Office of Research and Development, Washington D.C., July; EPA/600/R-92/128.

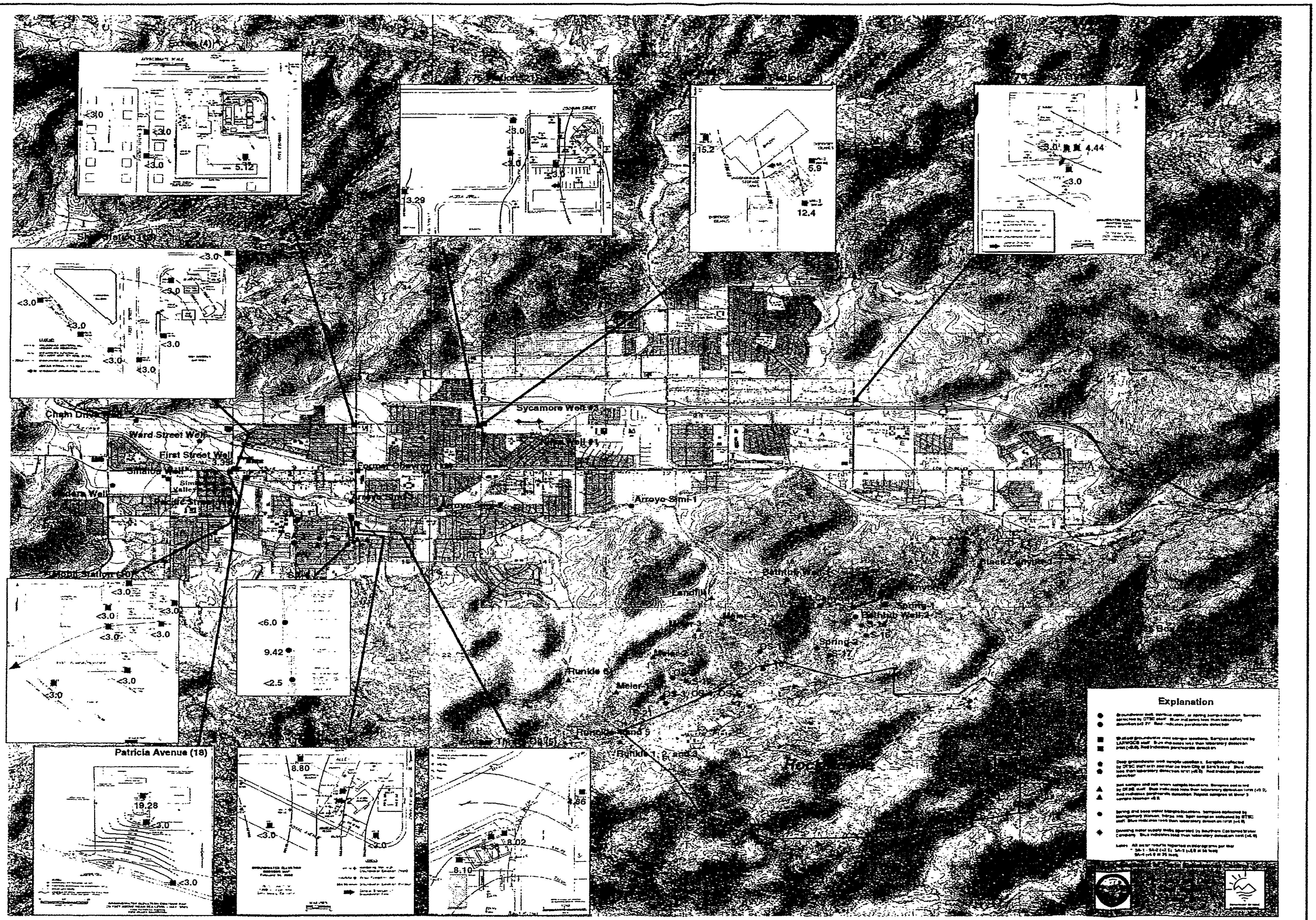
USEPA. 1989b. *Preparation of soil sampling protocol. Techniques and strategies.* EPA Environmental Monitoring Systems Laboratory, Office of Research and Development. Las Vegas, NV: Environmental Protection Agency, May 1983; EPA 600/4-83-020.

USEPA. 1989a. *Soil sampling quality assurance user's guide.* EPA Environmental Monitoring Systems Laboratory, Office of Research and Development. Las Vegas, NV: Environmental Protection Agency, March 1989; EPA 600/8-89/046.

USEPA. 1983a. *Characterization of hazardous waste sites - A methods manual.* Vol. 2, *Available sampling methods.* EPA Office of Research and Development, Environmental Monitoring Systems Laboratory. Las Vegas, NV: Environmental Protection Agency, September 1983; EPA 600/4-83-040.

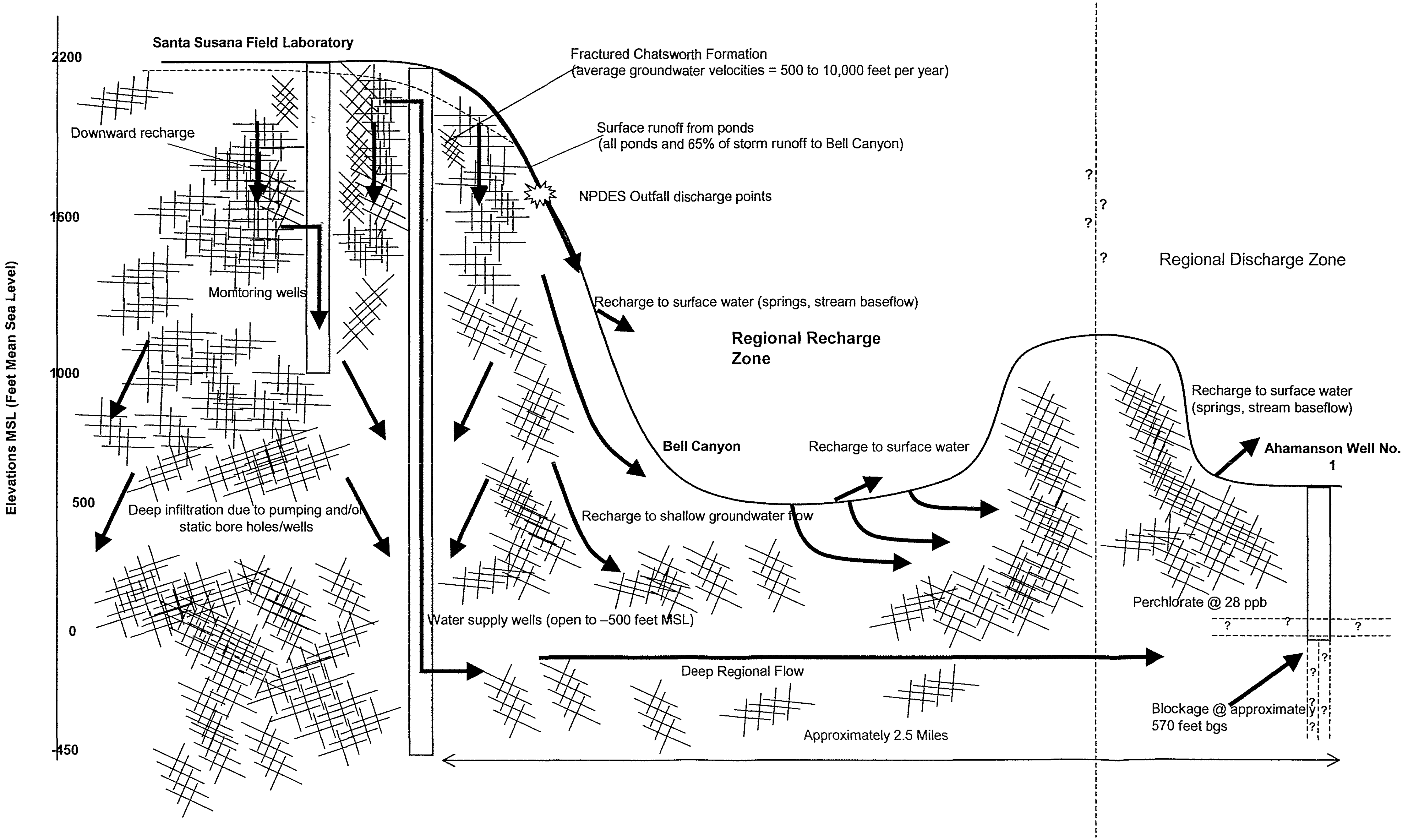
# FIGURES


SANTA SUSANNA FIELD LABORATORY
PROPOSED AHMANSON RANCH DEVELOPMENT
WELL NO. 1
CALABASAS LANDFILL
Simi Valley
Airport
Runkle Reservoir
Simi Peak
Chatsworth Peak
Chatsworth Lake Manor
UNDEVELOPED LAND
26
Oaks
Hidden Hills
Agoura
Calabasas
SAMPLE LOCATIONS
SAMPLE LOCATIONS W/PERCHLORATE DETECT
4.44 PERCHLORATE CONCENTRATIONS (ppb)
ALL SAMPLE LOCATIONS ARE APPROXIMATE
Printed from TOPO! ©2000 Wildflower Productions (www.topo.com)
CLIENT LOCATION AND DATA



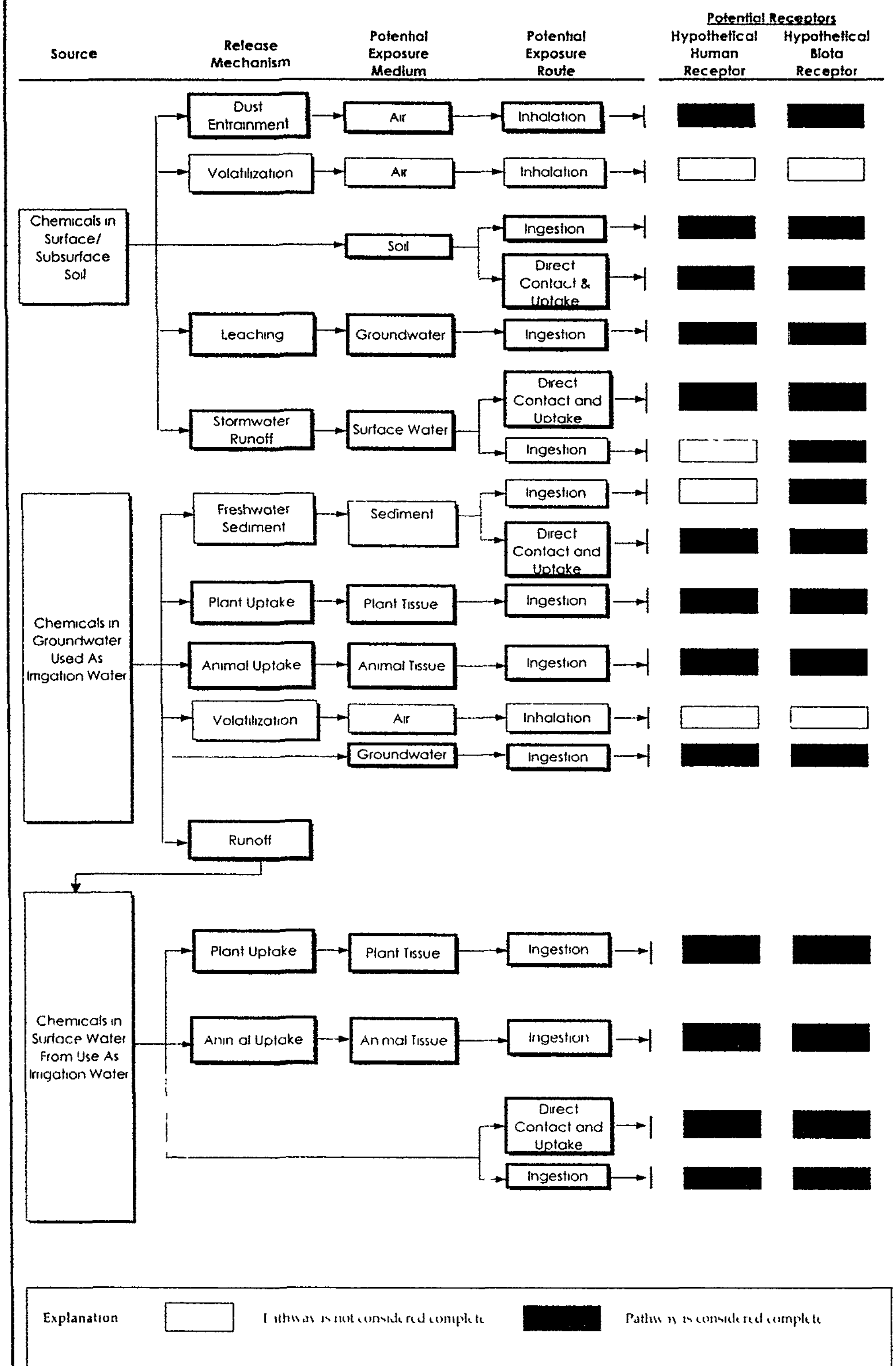

| | | | |
|---|---|---|---|
| DRAWN BY | SWO | TITLE | CLIENT LOCATION AND DATA |
| CHECKED BY | | | |
| PROJECT NO | 254-001 | LOCATION | SIMI VALLEY, CALIFORNIA |
| FILE NAME | | | FIG. NO 2 |
| DATE DRAWN | 12-12-02 | CLIENT | Ahmanson Ranch |
| DATE REVISED | | | |

# Conceptual Regional Groundwater Model




| | | |
|---|---|---|
| DRAWN BY: SWD | TITLE: CONCEPTUAL REGIONAL GROUNDWATER MODEL | |
| CHECKED BY: | | |
| PROJECT NO.: 254-001 | LOCATION: SIMI VALLEY, CALIFORNIA | FIG. NO.: 3 |
| FILE NAME: | | |
| DATE DRAWN: 12-12-02 | CLIENT: Ahmanson Ranch | |
| DATE REVISED: | | |

# Site Conceptual Model




SITE CONCEPTUAL MODEL

SIMI VALLEY CALIFORNIA

Ahmanson Ranch

4